21st International Conference Nuclear Energy for New Europe
LJUBLJANA 2012
September 5 – 7

Nucleonica:

Web-based Software Tools for Simulation and Analysis

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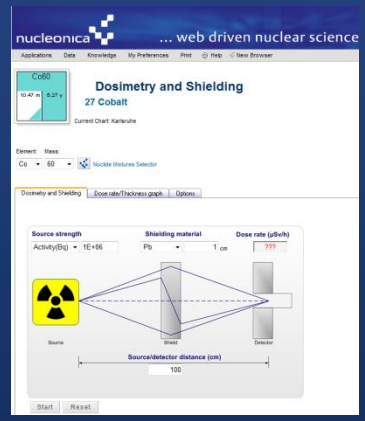
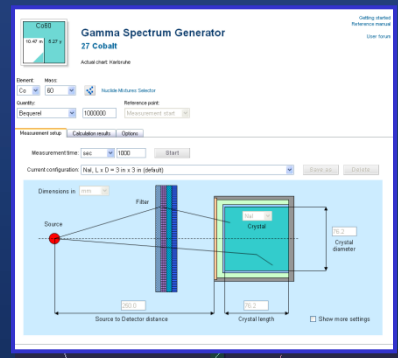
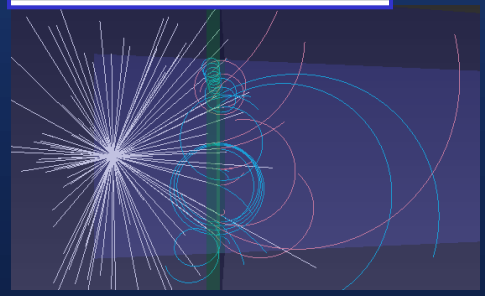
Nucleonica GmbH,
Karlsruhe

Nucleonica: Web-based Software Tools for Simulation and Analysis

- Nuclear Data Resources in Nucleonica
- Nuclear Science Applications & Tools
  - Decay Engine
  - Dosimetry & Shielding
  - Virtual Cloud Chamber
  - Gamma Spectrum Generator
  - webKORIGEN
  - *e*-Ship
- Education & Training with Nucleonica
  - Post Grad. Research
  - Nucleonica Mobile
  - Karlsruhe Nuclide Chart
- Knowledge Management with Nucleonica





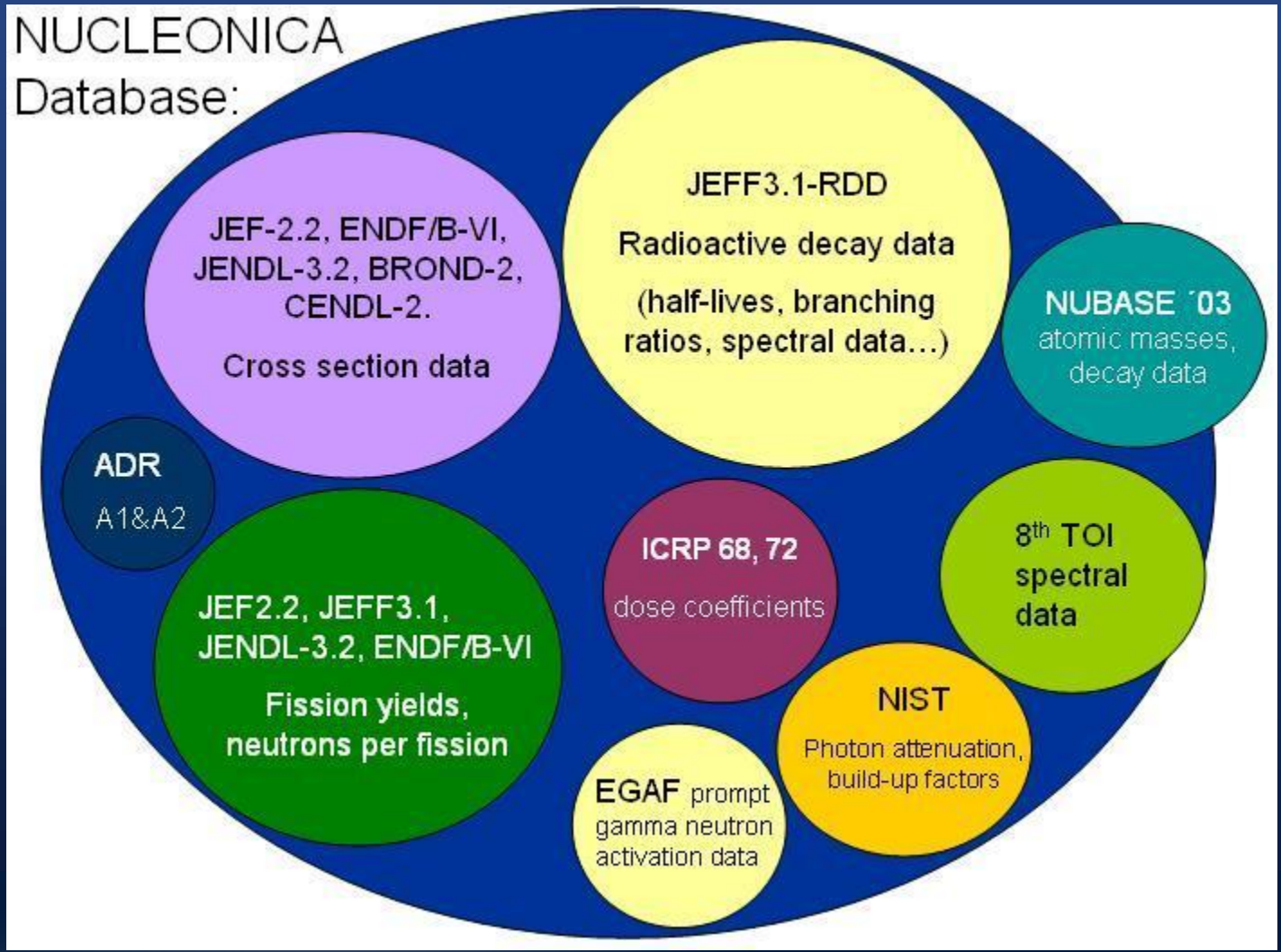


Nuclear Data Resources in Nucleonica

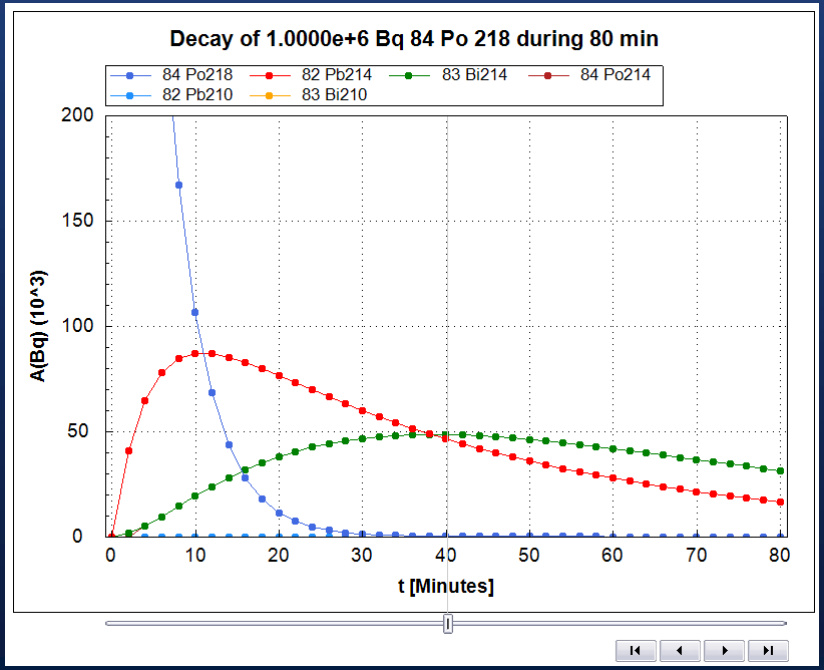
Main Nucleonica database JEFF3.1 contains decay data on 3852 nuclide.

NUBASE data on the atomic weights, binding energies, mass excesses, and abundances,

Additional sources: 8th Table of Isotopes, NIST, Fission Yields, ICRP does coeffs. The A1 and A2 from the IAEA. Properties of the elements (densities, melting points, boiling points etc.) and tables of physical constants, conversation factors and radiological limits are from the most recent evaluations.



Decay Engine



nucleonica ... web driven nuclear science

Applications Data Knowledge My Preferences Print Networking Nuclear Science Help New Browser

Po218
3.1 m

Decay engine

84 Polonium

Current Chart: Karlsruhe

Element Po | Mass 218 | Mixture selector

Decay Engine | Options | Decay Tree | Mixture details

Time Unit: Minutes
Decay Time: 80
Starting quantity: 1.0000e+6
Final quantity: 7.92E+04
Unit: Becquerel

Start | Reset | Create Nuclide Mixture

Calculation details

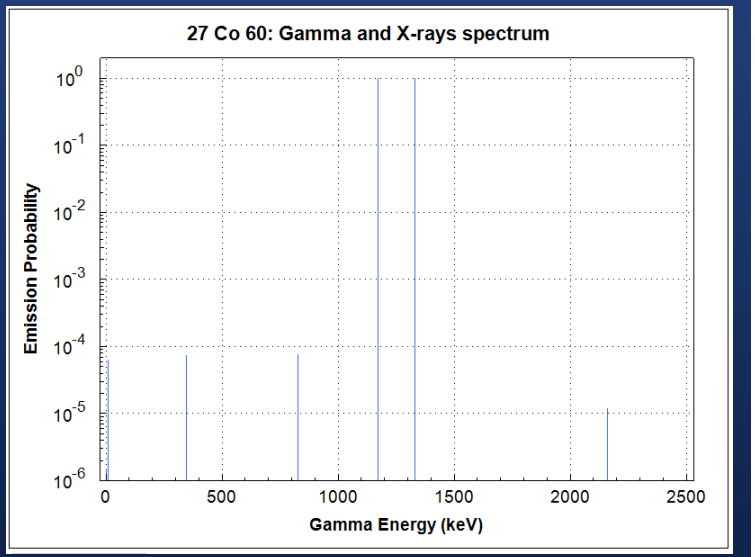
Number of timesteps:	40
Accuracy Factor:	1E-02
Distance (cm):	100
Number of linear chains:	1

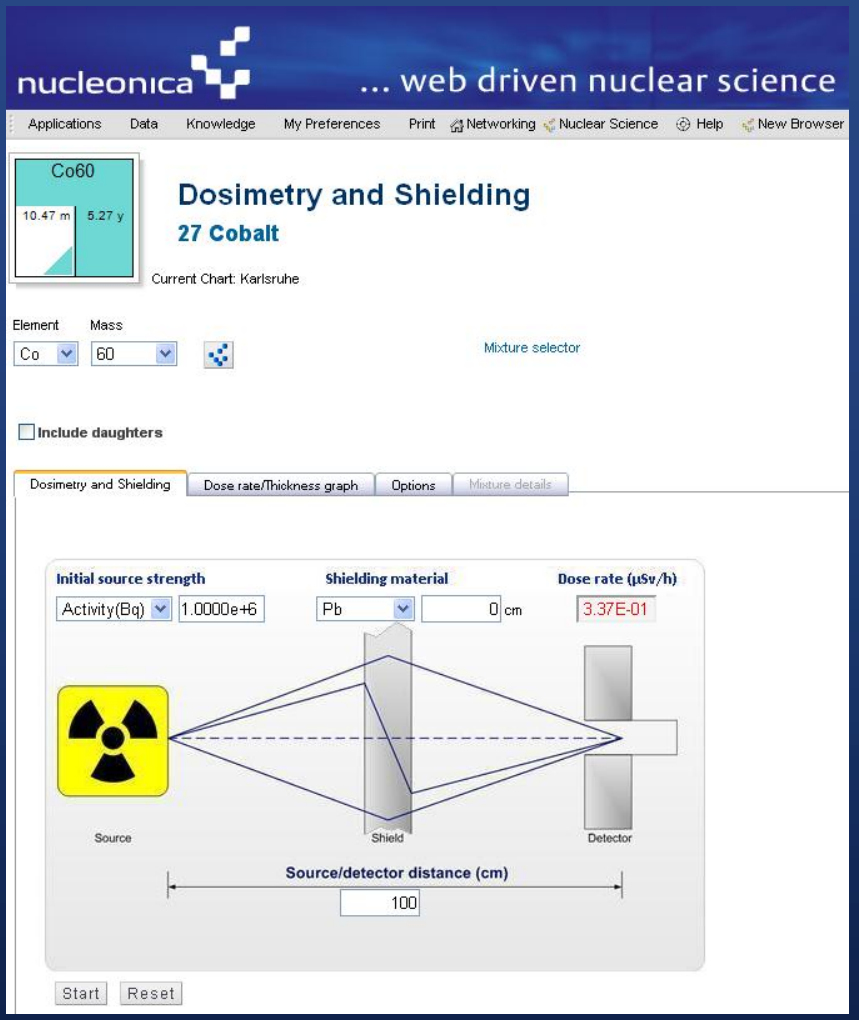
Plot	Parent+Daughters	Half-life	Decay modes	N(atoms)	A(Bq)	A_{α}(Bq)	A_{β^-}(Bq)	G(keV/s)
☑	84 Po218	3.1 m	α; β-	4.52E+00	1.68E-02	1.68E-02	3.20E-06	1.55E-04
☑	82 Pb214	26.8 m	β-	3.83E+07	1.65E+04	0	1.65E+04	3.61E+06
☑	83 Bi214	19.9 m	β-; α; β-,α	5.40E+07	3.13E+04	7.52E+00	3.13E+04	4.82E+07
☑	84 Po214	1.6E2 µs	α	7.40E+00	3.13E+04	3.13E+04	0	2.64E+03
☑	82 Pb210	22.17 y	β-; α	1.76E+08	1.74E-01	3.31E-09	1.74E-01	3.42E-01
☑	83 Bi210	5.01 d	β-; α	3.75E+02	6.00E-04	7.92E-10	6.00E-04	1.76E-07
☐	84 Po210	1.4E2 d	α	0	0	0	0	0
☐	82 Pb206 Stable	stable		0	0	0	0	0
☐	2 He4 Stable	stable		4.44E+08	0	0	0	0
☑	Total: 9 Page: 1 / 1	0		7.12E+08	7.92E+04	3.13E+04	4.78E+04	5.18E+07

Validated Nuclear Science Applications & Tools

Dosimetry & Shielding

The D&S module in Nucleonica allows the user to calculate gamma dose rates from point sources of single nuclides and nuclide mixtures. The user interface is shown in figure.

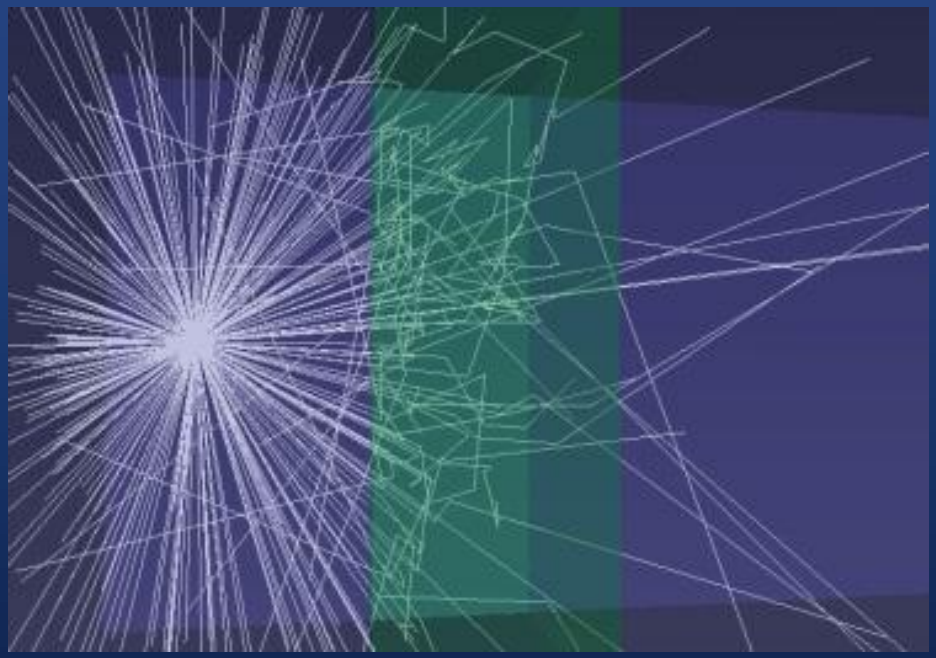




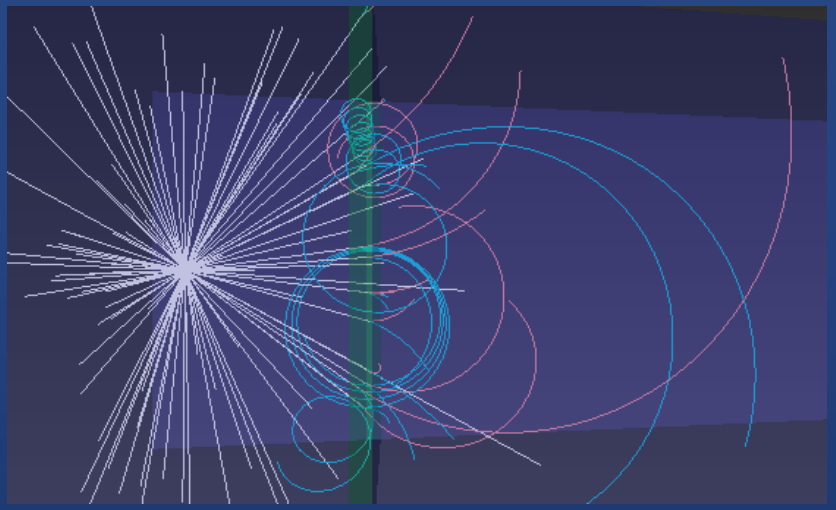
Gamma Energy (keV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm²/g)	Number of Mean Free Paths (µ·d)	Build-up Factor	Mass Absorption Coefficient (tissue)(cm²/g)	Tissue γ Dose Rate(µSv/h)	γ Exposure Rate(µGy/h)
1332.49	1.00E+00	0.00E+00	0.00E+00	1.00E+00	2.89E-02	1.77E-01	1.63E-01
1173.23	9.99E-01	0.00E+00	0.00E+00	1.00E+00	2.98E-02	1.60E-01	1.50E-01
826.1	7.60E-05	0.00E+00	0.00E+00	1.00E+00	3.16E-02	9.12E-06	8.30E-06
347.14	7.50E-05	0.00E+00	0.00E+00	1.00E+00	3.21E-02	3.83E-06	3.44E-06
2158.57	1.20E-05	0.00E+00	0.00E+00	1.00E+00	2.52E-02	2.99E-06	2.78E-06
2505.69	2.00E-08	0.00E+00	0.00E+00	1.00E+00	2.40E-02	5.51E-09	5.36E-09
7.47815	6.44E-05	0.00E+00	0.00E+00	1.00E+00	1.22E+01	0.00E+00	0.00E+00
7.46089	3.27E-05	0.00E+00	0.00E+00	1.00E+00	1.23E+01	0.00E+00	0.00E+00
8.26	1.31E-05	0.00E+00	0.00E+00	1.00E+00	9.01E+00	0.00E+00	0.00E+00
0.85	1.49E-06	0.00E+00	0.00E+00	1.00E+00	5.38E+03	0.00E+00	0.00E+00
Page: 1 / 1						3.37e-1	3.13e-1

Validated Nuclear Science Applications & Tools

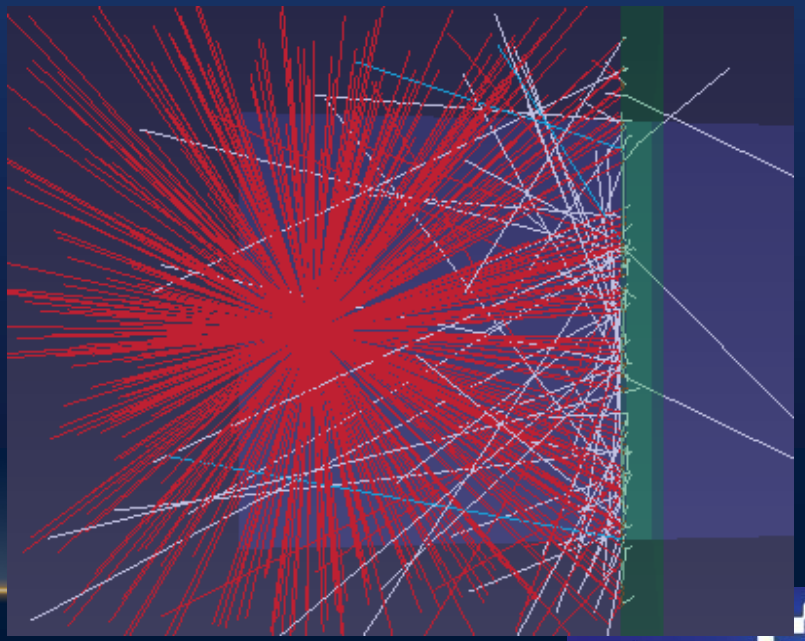
Virtual Cloud Chamber



low energy photons (energy 100 keV) are attenuated with a thick (15 cm) water shield. This combination of low energies and thick shields give rise to multiple scattering of the radiation



Electron-positron pairs are created using 10 MeV photons on lead. By “switching off” energy loss mechanisms, the charged particles are seen to spiral in the applied magnetic field.



The red particles (3 MeV positrons) are blocked by a lead shield (green). When the positrons collide with the shield, they combine with electrons (blue) to create gamma radiation (white). Only a few gamma photons pass through the shield material.

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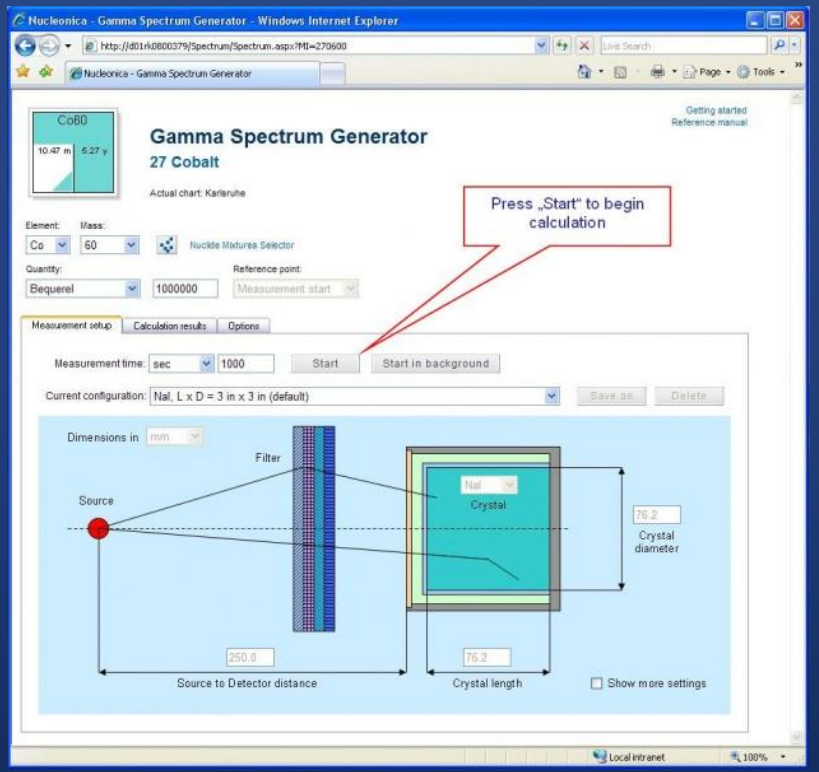
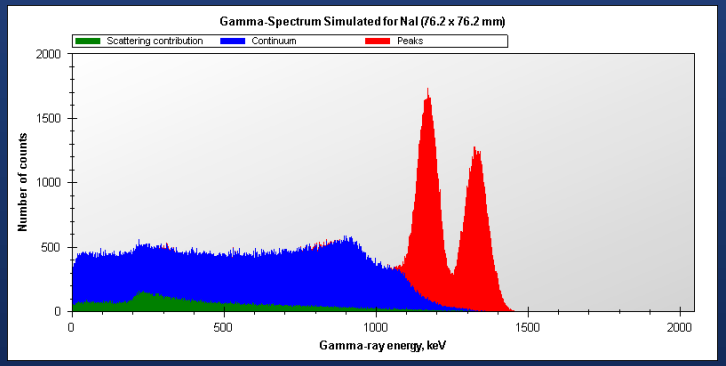
Validated Nuclear Science Applications & Tools

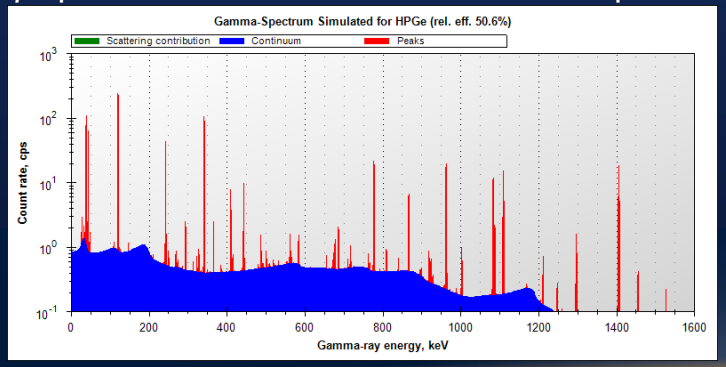
Gamma Spectrum Generator

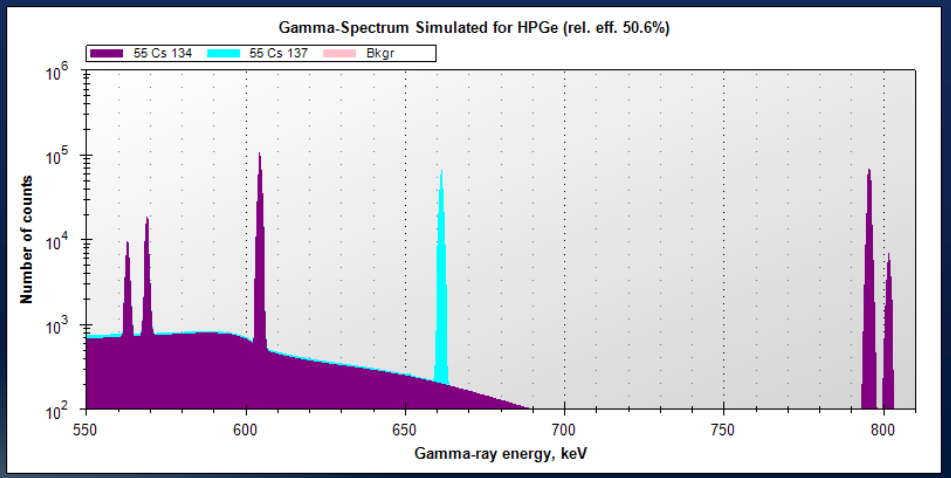


γ-spectrum simulated for ^{60}Co 100 kBq source and NaI (3" × 3") detector:



γ-spectrum simulated for ^{152}Eu 100 kBq source and HPGe detector.





Fukushima: Gamma spectrum of contamination at the Daiichi plant.
Contamination is almost entirely to cesium-137 and cesium -134

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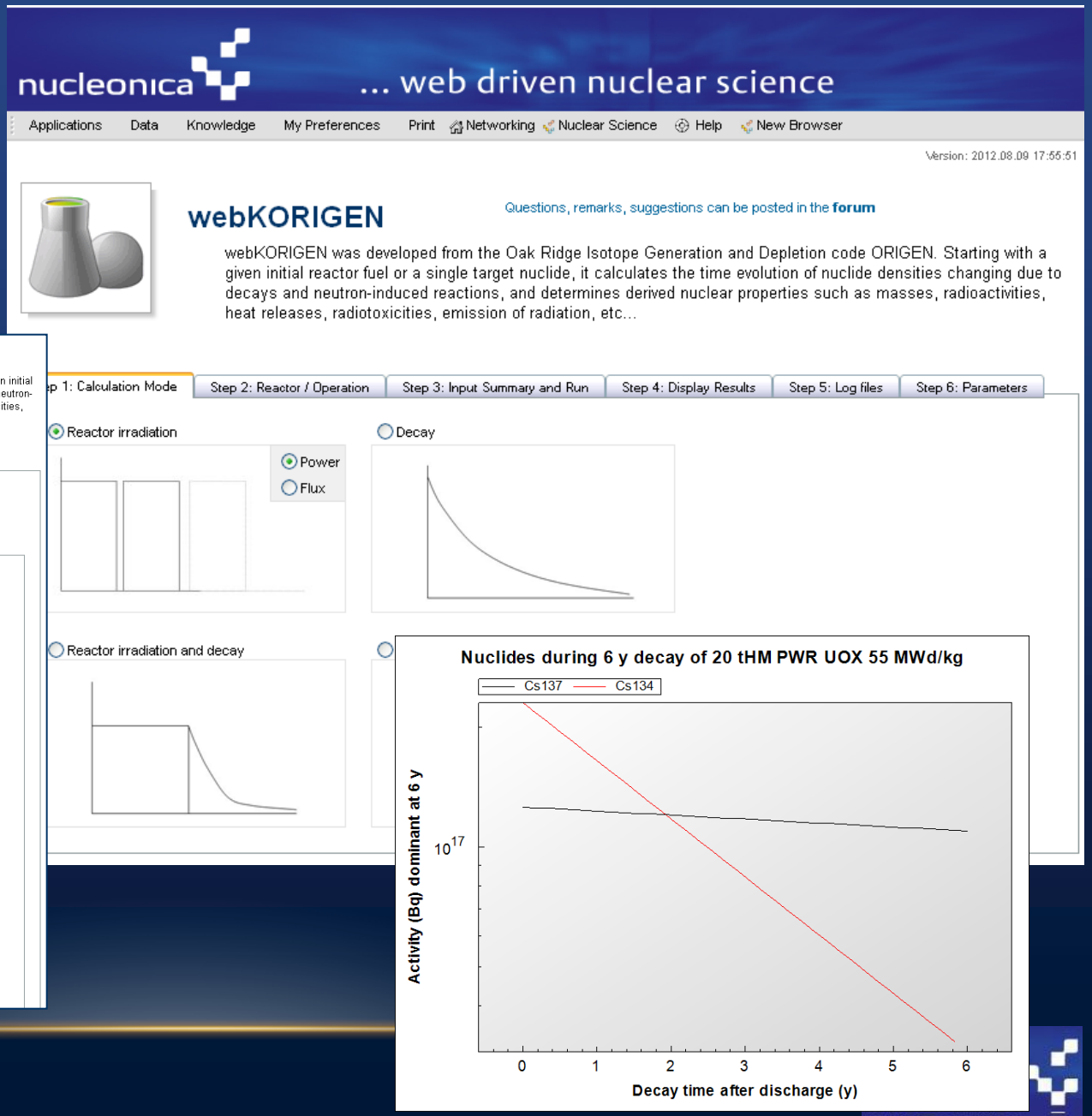
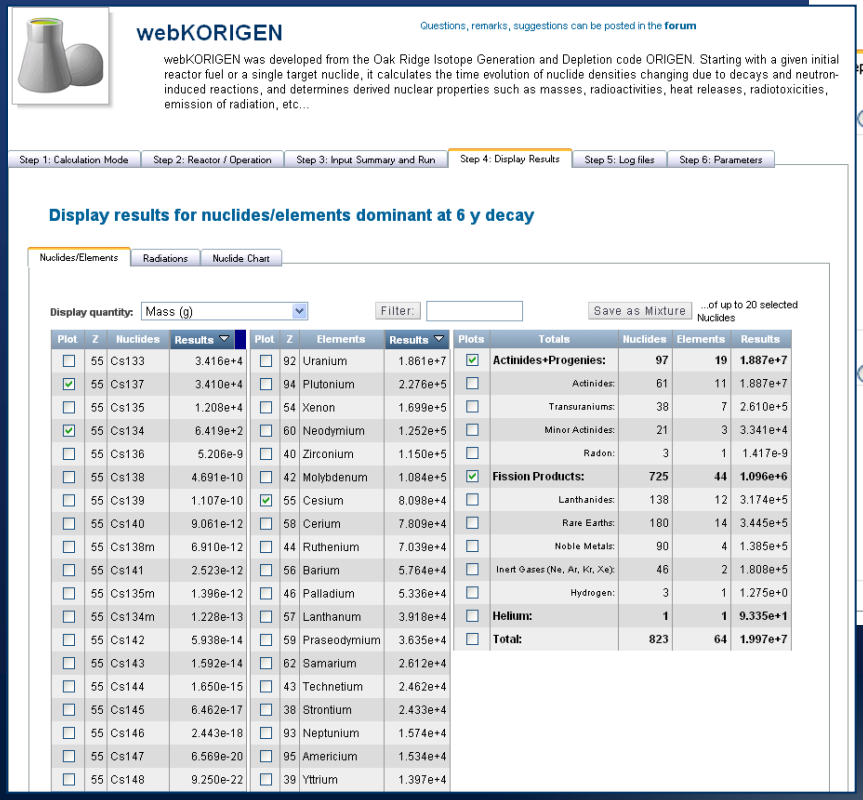
webKORIGEN





Validated Nuclear Science Applications & Tools

e-Ship: radioactive transport assistant

Nuclear material transport report

Transport report generated for source: Pu-241 with daughters by magill on 8/14/2012 2:01:20 PM

Source: Pu-241 with daughters
The sample - initially 15mg Pu-241. The sample is cooled for a period of 8 years and is solid, non-special form. the daughters Am-241, Np-237, and Pa-233 Pu-241 - 15 mg, 8 years old - Solid, Non special form
Form: Material, Other form, Solid
Matrix mass: 1 g

Source characterisation

Nuclide	Mass (g)	Activity (Bq)	Heat (W)	Gamma dose rate H_{10}(µSv/h) at 10 cm
Am-241	4.77e-3	6.05e+8	5.44e-4	1.15e+3
Np-237	3.20e-5	8.35e+2	6.59e-10	1.50e-3
Pa-233	1.06e-12	8.15e+2	5.38e-11	3.34e-3
Pu-241	1.02e-2	3.90e+10	3.34e-5	3.90e+3
Total:4	**1.50e-2**	**3.96e+10**	**5.78e-4**	**5.05e+3**

Package characterisation

Nuclide	Activity (Bq)	Exempt (Bq)	Excepted (GBq)	A_2 (TBq)	A / Exempt	A / Excepted	A / A_2
Am-241	6.05e+8	1.00e+4	1.00e-3	1.00e-3	6.05e+4	6.05e+2	6.05e-1
Np-237	8.35e+2	1.00e+3	2.00e-3	2.00e-3	8.35e-1	4.18e-4	4.18e-7
Pa-233	8.15e+2	1.00e+7	7.00e-1	7.00e-1	8.15e-5	1.16e-6	1.16e-9
Pu-241	3.90e+10	1.00e+5	6.00e-2	6.00e-2	3.90e+5	6.50e+2	6.50e-1
Total:4	**3.96e+10**				**4.51e+5**	**1.26e+3**	**1.26e+0**

Type B Package

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Applications Data Knowledge My Preferences Print Networking Nuclear Science Help New Browser

e-Ship
radiological transport service

My Packages | Edit | Options | Import | Activity limits | CERN file | Sample packages | About e-Ship

User defined transport packages

ID	Package Name	Matrix mass (g)	Source	Form	State	Modified	Delete
	(Create, import a new package)						
6	Electronic irradiated protons	1	Material	Other	Solid	2012.07.26 15:03:36	
5	Manual	1	Material	Other	Solid	2012.07.24 14:01:11	
4	Proton irradiated iron	1	Material	Other	Solid	2012.07.24 13:41:05	
38	Pu-241	15	Article	Other	Solid	2012.08.14 09:34:45	
11	Pu-241 with daughters	1	Material	Other	Solid	2012.08.10 09:05:09	
18	test	1	Material	Other	Solid	2012.07.26 15:22:04	
27	test GDR	1	Material	Other	Solid	2012.08.02 10:50:25	
37	testCo	1	Material	Other	Solid	2012.08.08 13:07:58	
19	U-233	1	Material	Other	Solid	2012.07.25 14:40:51	

e-Ship
radiological transport service

Questions, remarks, suggestions can be posted in the **forum**

My Packages | Edit | Options | Import | Activity limits | CERN file | Sample packages | About e-Ship

Name (ID=11)
Pu-241 with daughters
Description:
The sample - initially 15mg Pu-241.
The sample is cooled for a period of 8 years and is solid, non-special form.
It now contains the daughters Am-241, Np-237, and Pa-233
Pu-241

Excepted Packages
Source: Material / Instruments / Articles
Form: Other / Special
State: Solid / Liquid / Gas
Matrix mass: 1 g

Nuclide	Activity A (Bq)	Mass (g)	A_1 (TBq)	A_2 (TBq)	Excepted (GBq)	Exempt (Bq)	A / A_2	A / Excepted	A / Exempt	Gamma dose rate H_{10}(µSv/h) @ 10 cm	Delete
Am-241	6.05E+08	4.77e-3	10	0.001	1.00e-3	10000	0.605	605	6.05e+4	1.15e+3	
Np-237	8.35E+02	3.20e-5	20	0.002	2.00e-3	1000	4.18e-7	4.18e-4	0.835	1.50e-3	
Pa-233	8.15E+02	1.06e-12	5	0.7	0.700	1.00E+07	1.16e-9	1.16e-6	8.15e-5	3.34e-3	
Pu-241	3.90E+10	1.02e-2	40	0.06	6.00e-2	1.00E+05	0.650	650	3.90e+5	3.90e+3	
4	3.961e+10	1.500e-2					1.26	1.26e+3	4.51e+5		

Nuclide: Pu-241 | Quantity: 3.90E+10 | Unit: Bequerel | Update

Save Package | Reset | Cancel | Report | Save as Sample

nucleonica

Post-graduate research using Nucleonica

Nucleonica is currently being used by students for post-graduate research e.g.:

• Ph.D study of nuclear fuel cycles: The main goal is compare the amount of HLW which is stored and/or disposed for different fuel cycles, normalized to the same energy production.

• MPhil studies on modelling of atmospheric dispersion of radionuclide release from a research reactor. The aim is to compute: a) activity inventories of important radionuclides in the reactor core; b) release fractions; and c) activity released (to the atmosphere).

• Ph.D. studies medical physics: simulation of a HPGe detector used in the laboratory using the Gamma Spectrum Generator application.

• Ph.D. studies on Monte Carlo dosimetry calculations. Development of a general dosimetry and shielding application based on the CERN code GEANT4.

• MPhil studies on performance assessment of a borehole disposal facility for sealed radioactive sources. Various Nucleonica tools will be used for decay calculations, heat generation, gamma emission, neutron emission, external and internal radiotoxicities, etc.

Many of the technical problems arising in the course of these studies have been discussed on the Nucleonica Forum. Finally, we hope to be able to host the final reports from these studies on the Nucleonica web portal.

Education & Training with Nucleonica

Nucleonica for Smartphones: M-Learning

Education & Training with Nucleonica

Karlsruhe Nuclide Chart

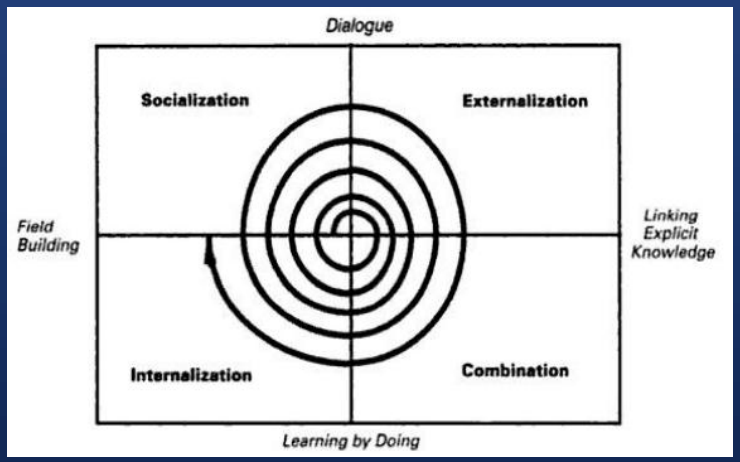
- Fold-out Chart
- Wall-Chart
- Auditorium Chart
- Nuclide Carpet

Nuclide „carpet“
1m x 6.5m

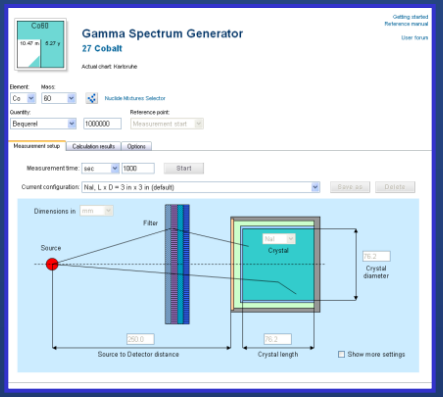
nucleonica

Knowledge Management with Nucleonica

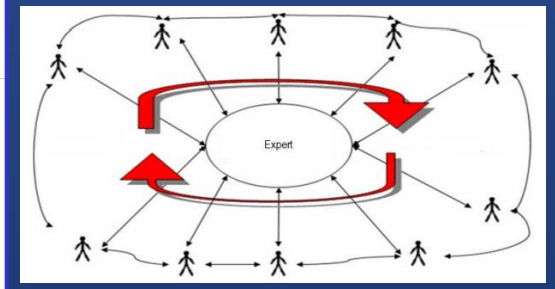
In this slide, the Nucleonica web portal is considered from a knowledge management perspective. Nonaka and Takeuchi have proposed the “knowledge spiral” (shown) in which there are four modes of knowledge conversion: socialization, externalization, combination and internalization (SECI model).



Socialisation: conversion of tacit knowledge to tacit knowledge e.g. an apprentice who works with tutor and learns from observing and imitating the tutor's actions. **Externalization:** conversion of tacit to explicit knowledge. **Combination** is the conversion of explicit to explicit knowledge. The process of systemizing already explicit knowledge into a knowledge system. **Internalization** is the conversion from explicit to tacit, which is closely related to “learning by doing”. At the end of the spiral process, one or more individuals in the organisation have acquired new tacit knowledge.

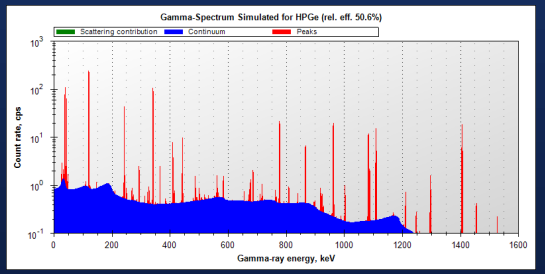


Socialisation: conversion of tacit knowledge to tacit knowledge



Externalization: conversion of tacit to explicit knowledge

Combination: systemizing explicit knowledge



Internalization: conversion from explicit to tacit, triggered through “Learning by Doing”.

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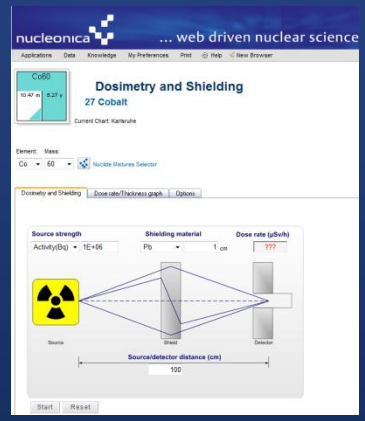
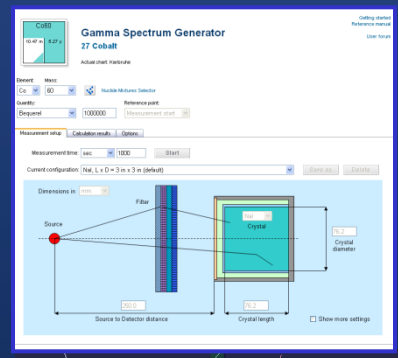
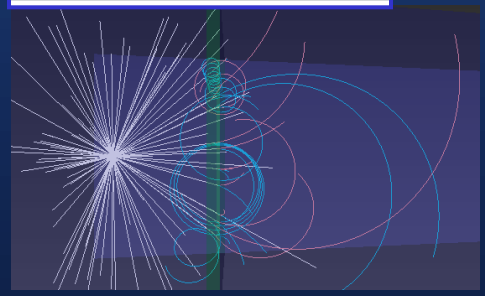
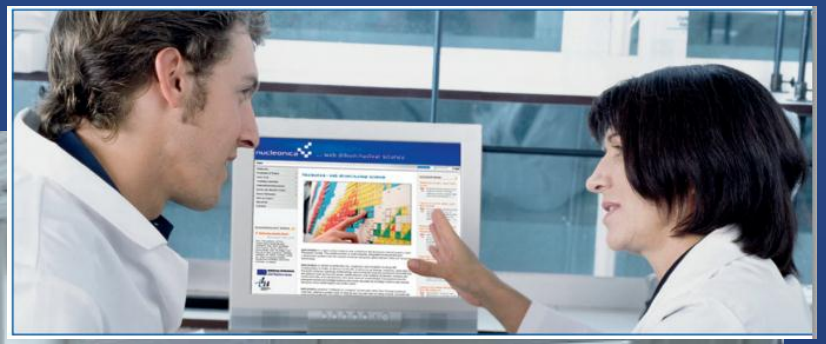






The next training course will take place on **25-26 October 2012** at the Karlsruher Institut für Technologie (KIT), FTU · Center for Advanced Technological and Environmental Training, KIT - Campus-Nord - Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen.



Thank You!